General

Guideline Title

ACR Appropriateness Criteria® stress (fatigue/insufficiency) fracture, including sacrum, excluding other vertebrae.

Bibliographic Source(s)

Bencardino JT, Stone TJ, Roberts CC, Appel M, Baccei SJ, Cassidy RC, Chang EY, Fox MG, Greenspan BS, Gyftopoulos S, Hochman MG, Jacobson JA, Mintz DN, Mlady GW, Newman JS, Rosenberg ZS, Shah NA, Small KM, Weissman BN, Expert Panel on Musculoskeletal Imaging. ACR Appropriateness CriteriaÂ® stress (fatigue/insufficiency) fracture, including sacrum, excluding other vertebrae. Reston (VA): American College of Radiology (ACR); 2016. 17 p. [83 references]

Guideline Status

This is the current release of the guideline.

This guideline updates a previous version: Daffner RH, Weissman BN, Appel M, Bancroft L, Bennett DL, Blebea JS, Bruno MA, Fries IB, Hayes CW, Kransdorf MJ, Luchs JS, Morrison WB, Palestro CJ, Roberts CC, Stoller DW, Taljanovic MS, Tuite MJ, Ward RJ, Wise JN, Zoga AC, Expert Panel on Musculoskeletal Imaging. ACR Appropriateness Criteria® stress (fatigue/insufficiency) fracture, including sacrum, excluding other vertebrae. [online publication]. Reston (VA): American College of Radiology (ACR); 2011. 9 p. [40 references]

This guideline meets NGC's 2013 (revised) inclusion criteria.

Recommendations

Major Recommendations

ACR Appropriateness Criteria®

Clinical Condition: Stress (Fatigue/Insufficiency) Fracture, Including Sacrum, Excluding Other Vertebrae

Variant 1: Suspected stress (fatigue) fracture, excluding vertebrae. First imaging modality.

Radiologic Procedure	Rating	Comments	RRL*
X-ray area of interest	9		Varies
MRI area of interest without IV contrast	1		O
MRI area of interest without and with IV contrast	1		O
CT area of interest without IV contrast	1		Varies
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative**

Radiologic Procedure	Rating	Comments	RRL*
CT area of interest with IV contrast	1		Varies
CT area of interest without and with IV contrast	1		Varies
Tc-99m bone scan whole body with SPECT area of interest	1		☢☢☢
US area of interest	1		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 2: Suspected stress (fatigue) fracture, hip. Negative radiographs. Next imaging study.

Radiologic Procedure	Rating	Comments	RRL*
MRI hip without IV contrast	9		O
Tc-99m bone scan whole body with SPECT hip	6	Timing of the study after injury and age of the patient are important considerations.	☢☢☢
X-ray hip repeat in 10 to 14 days	5	Because of the high risk of complications, it is not advisable to wait 10 to 14 days in most cases.	☢☢☢
CT hip without IV contrast	5	This procedure may be useful if MRI cannot be performed.	☢☢☢
MRI hip without and with IV contrast	1		O
CT hip with IV contrast	1		☢☢☢
CT hip without and with IV contrast	1		☢☢☢
US hip	1		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 3: Suspected stress (fatigue) fracture, excluding hip and vertebrae. Negative radiographs. Next imaging study.

Radiologic Procedure	Rating	Comments	RRL*
X-ray area of interest repeat in 10 to 14 days	9		Varies
MRI area of interest without IV contrast	8	This procedure is an equivalent option. It may be used preferentially in high-risk locations.	O
CT area of interest without IV contrast	5	This procedure may offer complementary information to MRI.	Varies
Tc-99m bone scan whole body with SPECT area of interest	5	Timing of the study after injury and age of the patient are important considerations.	☢☢☢
MRI area of interest without and with IV contrast	1		O
CT area of interest with IV contrast	1		Varies
CT area of interest without and with IV contrast	1		Varies
US area of interest	1		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

<u>Variant 4</u>: Suspected stress (fatigue) fracture, excluding vertebrae. Negative radiographs. Immediate "need-to-know" diagnosis. Next imaging study.

Radiologic Procedure	Rating	Comments	RRL*
MRI area of interest without IV contrast	9		O
CT area of interest without IV contrast	5	This procedure may show complementary information to MRI.	Varies
Tc-99m bone scan whole body with SPECT area of interest	5		☢☢☢
X-ray area of interest	1		Varies
MRI area of interest without and with IV contrast	1		O
CT area of interest with IV contrast	1		Varies
CT area of interest without and with IV contrast	1		Varies
US area of interest	1		O
<u>Rating Scale</u>: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

<u>Variant 5</u>: Confirmed stress (fatigue) fracture, excluding vertebrae. Follow-up imaging study for "return-to-play" evaluation.

Radiologic Procedure	Rating	Comments	RRL*
MRI area of interest without IV contrast	9		O
DXA total body composition	5	This procedure is not routinely done but may provide complementary information to MRI.	☢
CT area of interest without IV contrast	4	CT will not give prognostic information since stress fracture is already confirmed.	Varies
X-ray area of interest repeat in 10 to 14 days.	3	Repeat x-ray will not give prognostic information since stress fracture is already confirmed.	Varies
MRI area of interest without and with IV contrast	1		O
CT area of interest with IV contrast	1		Varies
CT area of interest without and with IV contrast	1		Varies
Tc-99m bone scan whole body with SPECT area of interest	1	Data are lacking. SPECT may show presence or absence of healing progression.	☢☢☢
US area of interest	1		O
<u>Rating Scale</u>: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

<u>Variant 6</u>: Suspected stress (insufficiency) fracture, pelvis or hip. First imaging study.

Radiologic Procedure	Rating	Comments	RRL*
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative**

Radiologic Procedure	Rating	Comments	RRL*
X-ray area of interest	9	Pain may be difficult to localize. This procedure is less sensitive than radiographs of extremities.	Varies
MRI area of interest without IV contrast	3		O
MRI area of interest without and with IV contrast	1		O
CT area of interest without IV contrast	1	This procedure is better for pelvis (sacrum) and would also depend on age because of radiation dose.	Varies
CT area of interest with IV contrast	1		Varies
CT area of interest without and with IV contrast	1		Varies
Tc-99m bone scan whole body with SPECT area of interest	1		☢☢☢
US area of interest	1		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 7: Suspected stress (insufficiency) fracture, pelvis or hip. Negative radiographs. Next imaging study.

Radiologic Procedure	Rating	Comments	RRL*
MRI area of interest without IV contrast	9		O
CT area of interest without IV contrast	7	This procedure is not as sensitive as MRI but remains a reasonable alternative.	Varies
Tc-99m bone scan whole body with SPECT area of interest	6	This procedure is less specific, but specificity may be age dependent.	☢☢☢
X-ray area of interest repeat in 10 to 14 days	4		Varies
MRI area of interest without and with IV contrast	1		O
CT area of interest with IV contrast	1		Varies
CT area of interest without and with IV contrast	1		Varies
US area of interest	1		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 8: Suspected stress (insufficiency) fracture of lower extremity, excluding pelvis and hip. First imaging study.

Radiologic Procedure	Rating	Comments	RRL*
X-ray lower extremity area of interest (not pelvis or hip)	9		☢
MRI lower extremity area of interest (not pelvis or hip) without IV contrast	1		O
MRI lower extremity area of interest (not pelvis or hip) without and with IV contrast	1		O
CT lower extremity area of interest (not			Varies
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Radiologic Procedure	Rating	Comments	RRL*
pelvis or hip) without IV contrast			
CT lower extremity area of interest (not pelvis or hip) with IV contrast	1		Varies
CT lower extremity area of interest (not pelvis or hip) without and with IV contrast	1		Varies
Tc-99m bone scan whole body with SPECT lower extremity area of interest	1		☢☢☢
US lower extremity area of interest (not pelvis or hip)	1		O
<u>Rating Scale</u>: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

<u>Variant 9</u>: Suspected stress (insufficiency) fracture of lower extremity, excluding pelvis and hip. Negative radiographs. Next imaging study.

Radiologic Procedure	Rating	Comments	RRL*
MRI lower extremity area of interest (not pelvis or hip) without IV contrast	9		O
X-ray lower extremity area of interest (not pelvis or hip) repeat in 10 to 14 days	7	This procedure is less sensitive than MRI but is a reasonable alternative.	☢
CT lower extremity area of interest (not pelvis or hip) without IV contrast	5		Varies
Tc-99m bone scan whole body with SPECT lower extremity area of interest	5		☢☢☢
MRI lower extremity area of interest (not pelvis or hip) without and with IV contrast	1		O
CT lower extremity area of interest (not pelvis or hip) with IV contrast	1		Varies
CT lower extremity area of interest (not pelvis or hip) without and with IV contrast	1		Varies
US lower extremity area of interest (not pelvis or hip)	1		O
<u>Rating Scale</u>: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

<u>Variant 10</u>: Follow-up imaging study for characterizing nonspecific focal uptake on Tc-99m MDP bone scintigraphy, suspected to be a stress fracture.

Radiologic Procedure	Rating	Comments	RRL*
X-ray area of interest	9		Varies
MRI area of interest without IV contrast	8	This procedure is an equivalent, more sensitive option to radiographs.	O
MRI area of interest without and with IV contrast	5	This procedure is useful if there is specific concern for malignancy or soft-tissue mass.	O
<u>Rating Scale</u>: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative**

Radiologic Procedure	Rating	Comments	RRL*
CT area of interest without IV contrast	5		Varies
CT area of interest with IV contrast	2	Contrast may be helpful it there is concern for malignancy. This procedure is used only if radiographs are negative and MRI cannot be performed.	Varies
CT area of interest without and with IV contrast	1		Varies
US area of interest	1		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 11: Suspect stress (fatigue or insufficiency) fracture, pelvis or hip or sacrum. Pregnant patient.

Radiologic Procedure	Rating	Comments	RRL*
MRI area of interest without IV contrast	9		O
X-ray area of interest	4		Varies
MRI area of interest without and with IV contrast	1		O
CT area of interest without IV contrast	1		Varies
CT area of interest with IV contrast	1		Varies
CT area of interest without and with IV contrast	1		Varies
Tc-99m bone scan whole body with SPECT lower extremity area of interest	1		☢☢☢
US area of interest	1		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 12: Suspect stress (fatigue or insufficiency) fracture of the long bones. Pregnant patient.

Radiologic Procedure	Rating	Comments	RRL*
X-ray area of interest	9	This procedure should be the first study.	Varies
MRI area of interest without IV contrast	8	This is a complementary study if initial radiographs are negative.	O
MRI area of interest without and with IV contrast	1		O
CT area of interest without IV contrast	1		Varies
CT area of interest with IV contrast	1		Varies
CT area of interest without and with IV contrast	1		Varies
US area of interest	1	This procedure may have some use but is much less sensitive than MRI.	O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Summary of Literature Review

Introduction/Background

Stress fractures occur in 2 varieties: 1) fatigue fractures resulting from repetitive submaximal stress on normal bone, resulting in a region of accelerated bone remodeling, and 2) insufficiency fractures due to normal activity on bones that are deficient in microstructure and/or mineralization. At the microscopic level, repetitive overloading leads to increased osteoclastic activity that exceeds the rate of osteoblastic new bone formation. This results in bone weakening and microtrabecular disruption (stress injury) and eventually may lead to a cortical break (stress fracture). Stress fractures are encountered frequently and account for up to 20% of all injuries seen in sports medicine clinics. Stress fractures are particularly common in athletes participating in activities that require running and jumping, as well as in ballet dancers and military recruits. On the other hand, we now recognize that certain medical interventions such as radiation therapy and long-term osteoporosis treatment with bisphosphonates predispose patients to stress fractures.

The use of magnetic resonance imaging (MRI) has greatly improved the ability to diagnose radiographically occult stress fractures. Both fatigue and insufficiency fractures are now being more frequently recognized as a source of pain in patients, and although fatigue and insufficiency fractures can be self-limited and go on to healing with or without diagnosis, there is usually value in making the diagnosis. With continued activity, some stress injuries and incomplete (unicortical) stress fractures will progress to completion and require more invasive treatment or delay in return to activity. Also, the differential diagnosis of fatigue/insufficiency fractures includes entities that would be treated significantly differently than stress fractures (osteoid osteoma or osteomyelitis in the younger patient, metastases in the older patient). The clinical picture is further clouded by the fact that many older patients with insufficiency fractures have histories of previous malignancy.

Overview of Imaging Modalities

Radiography

Radiography is the least expensive and most widely available imaging modality. Radiographs in at least 2 planes should be obtained as the initial imaging study in every patient suspected of having a stress fracture. Early radiographic findings are often nonspecific, for example, subtle periosteal reaction, "gray cortex" sign, or even nonexistent as initial radiographs have reported sensitives of only 15% to 35%. Over time, patients develop more specific radiographic findings, for example, linear sclerosis perpendicular to the trabeculae.

Tc-99m Bone Scintigraphy (Bone Scan)

The bone scan was regarded for many years as the gold standard for detecting stress-induced injuries and was valued for its sensitivity. One study reported the sensitivity, specificity, accuracy, positive predictive value, and negative predictive value of bone scintigraphy for detection of stress injuries as 92.9%, 73.8%, 83.3%, 78.0%, and 91.2%, respectively. Planar scintigraphy combined with single-photon emission computed tomography (SPECT) is more accurate in diagnosing stress injuries than planar scintigraphy alone. The objection to the studies quoting high accuracy for bone scintigraphy is that in all of them, positive bone scintigraphy is taken as the gold standard for detecting stress fractures and therefore sensitivity is 100%. However, depending on the staging criteria for bone scintigraphy pattern, the abnormalities may in fact be stress reactions rather than actual stress fractures. Nonetheless, it is clear that bone scintigraphy shows stress fractures days to weeks earlier than radiographs in many instances and differentiates between osseous and soft-tissue injury as well.

Magnetic Resonance Imaging

MRI is extremely sensitive and demonstrates stress abnormalities as early as bone scintigraphy and with as much sensitivity. The recent literature favors MRI as the procedure of choice for making an early diagnosis of both varieties of stress fractures. In this regard, MRI outperforms radiography, bone scintigraphy, and computed tomography (CT). Fluid-sensitive sequences are the favored initial sequence for MRI screening. With a small field of view, short tau inversion recovery and/or T1-weighted imaging will usually demonstrate a fracture line surrounded by edema. In the absence of an actual stress fracture, stress reaction or muscle/tendon injuries can be identified using fluid-sensitive sequences. Thus, MRI may be as sensitive as bone scintigraphy but also considerably more specific. Intravenous contrast is not needed for diagnosis and has yet to provide any additional information. MRI examination of an osseous stress injury contains prognostic as well as diagnostic information.

Computed Tomography

CT is not typically used as a first- or second-line imaging tool in the workup of stress fractures but may offer an adjunct role when other imaging modalities are equivocal, particularly in the pelvis or sacrum. Although superior to radiography, it is less sensitive than nuclear scintigraphy or MRI. The benefit of CT seems to lie in its specificity, ranging from 88% to 98% in a recent meta-analysis looking at diagnostic accuracy of imaging modalities for lower-extremity stress fractures, and thus may confirm a suspected stress fracture based on MRI. However, CT does involve ionizing radiation, so it is typically used only when MRI is equivocal. For the evaluation of stress fractures, intravenous contrast is not helpful as a part of CT examinations.

Ultrasound

There is limited evidence on the utility of ultrasound in diagnosing stress fractures. Ultrasound is a first-line imaging modality in assessing muscles, tendons, joints, and nerves in the extremities, so the radiologist should know the typical sonographic appearance of stress fractures. Sonographic findings of stress fractures include subcutaneous edema, periosteal thickening, cortical bone irregularity, local hyperemia, and periosteal callus. Overall, ultrasound appears to be more sensitive than specific, and similar ultrasound findings can be seen in osteomyelitis or neoplasm. Furthermore, ultrasound cannot evaluate the subcortical bone, so trabecular stress fractures may be missed. Although touted as cheap and quick to perform, it is limited as an operator-dependent modality.

Variant 1: Suspected Stress (Fatigue) Fracture, Excluding Vertebrae. First Imaging Study

In the setting of new or repetitive athletic activity, fatigue fractures can develop in patients with normal bone. Furthermore, certain athletic activities often result in specific sites of fatigue fracture, such as olecranon process fractures in javelin throwers and baseball pitchers, proximal femur and tibial stress fractures in runners, and tarsal navicular stress fractures in basketball players. Correlation of clinical history, pattern, and site recognition with radiographic findings is usually specific. Nevertheless, stress fractures are frequently occult on initial radiographs, with conventional radiographs having a sensitivity of 15% to 35%. Early radiographic findings are often nonspecific (subtle periosteal reaction, gray cortex sign) or even nonexistent. Late radiographic findings are often suggestive in appearance and include linear sclerosis (often perpendicular to the major trabecular lines), periosteal reaction, patchy endosteal sclerosis, and soft-tissue swelling. Additionally, radiographs may remain negative depending on the timing of reimaging, the patient's metabolic bone status, and the type and location of the fracture. Thus, radiographs are specific but significantly insensitive. Despite this limitation, all authorities agree that radiographs should be the initial imaging modality; if the findings are conclusive, no further imaging need be performed.

Variant 2: Suspected Stress (Fatigue) Fracture, Hip. Negative Radiographs. Next Imaging Study

Short-term (10 to 14 days) follow-up radiographs are more sensitive than initial radiographs secondary to overt bone reaction in the location of the stress fracture. Follow-up radiographic sensitivity increases to 30% to 70%. Detection of osseous change is more limited in areas covered by prominent overlapping soft tissue. If the osseous reaction involves cortical bone, then endosteal/periosteal callus may be visible with or without a fracture line through the cortex. If the trabecular bone is involved, then stress fractures are often more subtle, progressing from patchy areas of increased density into linear areas of sclerosis, oriented perpendicular to the trabeculae.

Although bone scans were regarded as the gold-standard examination for many years, MRI is extremely sensitive and demonstrates stress abnormalities as early as bone scintigraphy and with as much sensitivity. The recent literature favors MRI as the procedure of choice for making an early diagnosis of both varieties of stress fractures. In this regard, MRI outperforms radiography, bone scintigraphy, and CT. Furthermore, MRI examination of an osseous stress injury contains prognostic as well as diagnostic information.

CT is not typically used as a first- or second-line imaging tool but may offer an adjunctive role when other imaging modalities are equivocal. Although superior to radiography, it is less sensitive than nuclear scintigraphy and MRI.

Stress fractures in the femur most often occur in the femoral neck and represent up to 7% of all stress fractures. Lateral "tension-type" femoral neck stress fractures are inherently unstable and prone to displacement and are high-risk fractures, often necessitating percutaneous screw fixation. Medial "compression-type" femoral neck stress fractures are low risk and can be treated with a non–weight-bearing regimen. Finally, stress fractures of the femoral head are high risk in healthy patients and, if not recognized promptly, have increased rates of delayed union, nonunion, displacement, and avascular necrosis. Given the importance of recognizing these high-risk fractures in the femoral head and neck, MRI is the preferred second-line study after initial negative radiographs to prevent delayed diagnosis.

Variant 3: Suspected Stress (Fatigue) Fracture, Excluding Hip and Vertebrae. Negative Radiographs. Next Imaging Study

See variant 2. Certain stress fractures are considered high risk based on a tendency for nonunion or delayed union. High-risk stress fractures include the anterior tibial diaphysis, lateral femoral neck and femoral head (see variant 2), patella, medial malleolus, navicular, fifth metatarsal base, proximal second metatarsal, tibial hallux sesamoid, and talus.

The second-line test to diagnose a stress fracture should be guided by the location of the patient's pain and likelihood of high-risk injury. A follow-up radiographic examination has increased sensitivity compared to initial radiographs but is less sensitive than MRI. MRI is extremely sensitive and demonstrates stress abnormalities as early as bone scintigraphy and with as much sensitivity. The recent literature favors MRI as the procedure of choice for making an early diagnosis of both varieties of stress fractures. MRI is also considerably more specific than bone scintigraphy. Stress injuries in athletes that are not identified and managed in a timely fashion can progress to more serious fractures. Preventive strategies, including identifying and modifying risk factors, may help deter progression to frank fractures.

A circumstance that deserves specific attention is the longitudinal stress fracture, particularly in the tibia. Up to 25% may appear normal on radiographs, but CT or MRI findings are characteristic. MRI is very sensitive to the bone marrow edema accompanying these longitudinal fractures and may give a misleadingly aggressive appearance. However, axial CT alone can have false negatives because of the constraint of the axial plane (in one study, half of stress fractures were inadequately demonstrated on CT). Therefore, if CT is used to confirm stress fracture in a long bone, multiplanar reformatting is necessary. Fine detail can be achieved using thinner sections.

Variant 4: Suspected Stress (Fatigue) Fracture, Excluding Vertebrae. Negative Radiographs. Immediate "Need-to-Know" Diagnosis. Next Imaging Study

See variant 2. MRI is extremely sensitive and demonstrates stress abnormalities as early as bone scintigraphy and with as much sensitivity. The recent literature favors MRI as the procedure of choice for making an early diagnosis of both varieties of stress fractures. MRI is also considerably more specific than bone scintigraphy. Stress injuries in athletes that are not identified and managed in a timely fashion can progress to more serious fractures. Preventive strategies, including identifying and modifying risk factors, may help deter progression to frank fractures.

Variant 5: Confirmed Stress (Fatigue) Fracture, Excluding Vertebrae. Follow-up Imaging Study for "Return-to-Play" Evaluation

See variants 1 through 3. On initial diagnosis, MRI can be used to predict time to return to play in athletes. One study retrospectively correlated return to activity with an MRI grading system based on the pattern of periosteal and marrow edema on T1-weighted and fat-suppressed T2-weighted sequences. Similar findings were confirmed in other studies, including that the finding of abnormal cortical signal intensity or a fracture line was of prognostic value and that MRI performed better in predicting return to activity than radiographs, bone scintigraphy, or CT.

A recent prospective study in university athletes found that MRI grading severity, total-body bone mineral density evaluated by dual-energy x-ray absorptiometry (DXA), and location of injury (i.e., cortical or trabecular bone) were important variables for predicting time to full return to sport. In this study, periosteal edema as described was not associated with return to sport. Using the modified grading scale and a multiple regression model, for every 1-unit increase in MRI grade, the time to full return to sport increased by approximately 48 days. Furthermore, trabecular stress injuries (e.g., femur neck and pubic bone) were associated with a longer time to return to sport than cortical bone stress injuries. In addition, decreased bone mineral density leads to increased time to return to sport. Therefore, bone mineral density provides additional diagnostic and prognostic information. The model of MRI grade, trabecular versus cortical bone site, and total-body bone mineral density accounted for 68% of the variation in time to return to sport. Although further studies are needed, optimization of bone mass may reduce risk of sustaining stress injuries or possibly reduce recovery time in athletes with these injuries.

It should be noted that after a diagnosis of stress fracture is made, no additional imaging is typically performed. Patients are typically followed clinically until they are pain free, at which time they can increase activity in a controlled manner.

Variant 6: Suspected Stress (Insufficiency) Fracture, Pelvis or Hip. First Imaging Study

See variant 1. Pelvic and hip insufficiency fractures have varied presentations and often insidious onset. Patients frequently present with intractable lower back or pelvic pain, with loss of mobility and independence and symptom exacerbation with weight bearing. Insufficiency fractures occur in patients with abnormal bone, be it from osteoporosis, irradiated bone, or resumption of activity postarthroplasty as typical examples. Insufficiency fractures also occur at fairly predictable sites, including the sacrum, supra-acetabular ilium, superior and inferior pubic rami, and pubic bone. Radiographs should be the initial imaging modality in patients with low back and/or pelvic pain. Anterior-posterior (AP) and lateral lumbar spine and AP pelvis radiographs are usually obtained. Because of overlying bowel gas, fecal material, vascular calcifications, sacral curvature, and/or copious soft tissue, the sensitivity of radiographs is low. Radiographs may be more likely to be negative initially in older or osteoporotic patients with insufficiency fractures, particularly when they occur in the pelvis or sacrum where there is more overlapping soft tissue. However, if the findings are conclusive for insufficiency fracture, no further imaging need be performed.

Variant 7: Suspected Stress (Insufficiency) Fracture, Pelvis or Hip. Negative Radiographs. Next Imaging Study

Normal bone scintigraphy generally excludes a diagnosis of stress/fracture, and the patient can return to normal activity. However, there are exceptions. In elderly or osteoporotic patients, abnormalities may not show up on bone scintigraphy for several days postinjury. Patients using corticosteroids may also have less sensitive bone scintigraphy results. The characteristic "Honda" or "H" sign on bone scintigraphy is commonly referred to as diagnostic of sacral insufficiency fracture. A study confirmed this, finding a positive predictive value of 94% for the Honda sign; however, absence of the sign did not rule out a fracture, as only 63% of patients with sacral insufficiency fractures demonstrated this sign. In fact, there may be an overemphasis on the Honda sign, as many fractures are oriented in the sagittal plane, parallel to the sacroiliac joint. In most cases, bone scintigraphy lacks specificity (with synovitis, arthritis, degenerative joint disease, stress reactions, and tumor appearing similar), and supplemental imaging with MRI or CT may be necessary for conclusive diagnosis or to avoid false positives. Because bone scintigraphy is often nonspecific and time-consuming, and supplemental imaging is frequently required, there is consensus in the literature that cross-sectional imaging should supersede bone scintigraphy as the imaging of choice for suspected insufficiency fracture when the radiograph is negative.

It is recommended that cross-sectional imaging for hip fractures also include the sacrum, since stress fractures of the sacrum can be the source of radiated hip/groin pain. The choice of cross-sectional imaging modality in the evaluation of stress fractures of the sacrum has not always been clear-cut. CT is particularly well-suited for the evaluation of the sacrum and pelvis. If the patient was symptomatic for several weeks before imaging was performed, the CT images may show periosteal reaction, sclerosis, or the fracture lines themselves. Although the critical time for stress fracture to show up on MRI postinjury has not been established, it seems that the edema pattern would be present within hours. Studies have demonstrated that the MRI pattern can be nonspecific and even confusing when only edema and not the fracture line is shown. This problem seems particularly severe in differentiating sacral or pelvic insufficiency fractures from metastases. These fractures are being recognized with greater frequency as their occurrence has become more widely known.

Compounding the problem is the fact that many patients suffering from these insufficiency fractures have a history of previous malignancy, including treatment with radiation (which increases the risk of insufficiency fracture). Over-reliance on nonspecific low-signal T1 and high-signal T2 MRI patterns can lead to misdiagnosis of stress fractures as more aggressive lesions. The edema associated with stress fractures is typically much more pronounced and linear on T2-weighted sequences than on T1-weighted sequences; in patients with neoplasm, the lesion is typically more obvious on the T1-weighted sequence. The use of in-phase and out-of-phase MRI sequences appears to be more reliable in differentiating benign stress fractures from pathologic fractures. Normal marrow has both fat and water in the same voxel, which results in suppression of signal intensity on opposed-phase images. In a pathologic fracture, a tumor replaces the fat-containing marrow, which should show lack of suppression on the opposed-phase image. However, as described previously, many insufficiency fractures have characteristic locations, for example, the sacrum, supra-acetabular ilium, superior and inferior pubic rami, and pubic bones, and knowledge of the typical locations may add some diagnostic value.

Variant 8: Suspected Stress (Insufficiency) Fracture, Lower Extremity, Excluding Pelvis and Hip. First Imaging Study

See variants 1 and 5. Radiographs of the area of concern should be the initial imaging study. Although not very sensitive, if the findings are conclusive for insufficiency fracture, no further imaging need be performed.

Variant 9: Suspected Stress (Insufficiency) Fracture of Lower Extremity, Excluding Pelvis and Hip. Negative Radiographs. Next Imaging Study

See variant 2. Follow-up radiographs, MRI, CT, or bone scintigraphy can be used as subsequent imaging tests, based on the urgency to know the diagnosis and the patient's ability to tolerate the different examinations.

Variant 10: Follow-up Imaging Study for Characterizing Nonspecific Focal Uptake on Tc-99m MDP Bone Scintigraphy, Suspected to Be a Stress Fracture

Tc-99m methyl diphosphonate (MDP) is a marker of bone perfusion and bone turnover. Relative uptake is dependent on both the perfusion of a region of bone as well as the area of the mineralization front of bone (e.g., osteoid). Thus, there will be focal uptake in any location of new bone formation. Although bone scintigraphy is very sensitive for stress reactions and osteoblastic metastases, in most cases it lacks specificity, with synovitis, arthritis, degenerative joint disease, stress reactions, and tumor appearing similar. Supplemental imaging with radiographs, MRI, or CT may be necessary for conclusive diagnosis or to avoid false positives. Furthermore, MRI or CT should be performed without and with contrast when there is suspicion of neoplasm or soft-tissue mass adjacent to the area of abnormal bone.

Variant 11: Suspect Stress (Insufficiency) Fracture, Pelvis or Hip or Sacrum. Pregnant Patient

Pregnancy-related osteoporosis is rare and its pathogenesis is unclear. Patients are predisposed to develop insufficiency fractures in the spine, pelvis, femoral neck, wrist, or clavicle. Decreased serum calcium levels may occur during pregnancy because of decreased levels of 1,25-dihydroxyvitamin D_3, decreased calcitonin levels, and the effects of cytokines on bone remodeling. Insufficiency fractures of the sacrum secondary to postmenopausal or age-related osteoporosis are frequent and predicted to triple by the year 2030 secondary to raised awareness, advanced radiological methods of diagnosis, and increasing mean age. In contrast, fractures of the sacrum occurring during pregnancy, labor, or immediately postpartum are rare and only a few case reports have been published in the English literature, presenting as insufficiency fractures, fatigue fractures, and those where the authors were not sure if they were dealing with fatigue fractures or insufficiency fractures with underlying osteoporosis. Risk factors for fatigue sacral fractures during pregnancy and the postpartum period likely include vaginal delivery of a high-birth-weight infant, increased lumbar lordosis, excessive weight gain, and rapid vaginal delivery.

Imaging findings of pregnancy-related sacral fractures are similar to sacral insufficiency fractures related to involutional osteoporosis, with the exception that patients will be women in the reproductive years and in the last trimester of pregnancy or recently postpartum. Radiographs, if obtained, may be normal or demonstrate unilateral or bilateral linear areas of sclerosis. MRI does not use ionizing radiation and has excellent sensitivity, and it should be considered the imaging study of choice for definitive diagnosis. MRI typically demonstrates linear T1 and T2 hypointense signal, representing fracture lines, and T1 hypointense and T2 hyperintense signal in the surrounding bone marrow, representing associated edema. Bone scintigraphy and CT are both associated with radiation exposure to the fetus in a pregnant patient. There is currently insufficient evidence that gadolinium-based contrast agents are without risk to the fetus, so they are recommended in pregnancy only when information cannot be acquired from a noncontrast MRI.

For reference, the approximate mean fetal absorbed dose from a pelvis radiograph is 1.1 mGy, from a pelvis CT is 25 mGy, and from bone scintigraphy is 4.6 mGy (early in pregnancy) and 1.8 mGy (at 9 months estimated gestational age). The specific risk to radiating the fetus appears to be childhood malignancy, with theoretical projections suggesting that for each 10-mGy exposure there is a maximum risk of 1 additional cancer death per 1700 exposures. There are no diagnostic radiographic, CT, or nuclear medicine procedures to be considered a risk factor for genetic damage, malformation, or neurodevelopmental effects based on current knowledge.

Furthermore, MRI may also demonstrate other reasons for occult pelvic pain, such as soft-tissue abnormalities or the subchondral hip or supra-acetabular stress fractures described in some osteoporotic patients. The clinical differential diagnosis includes sacroiliitis from inflammatory or infectious causes, osteitis condensans ilii, and lumbosacral degenerative spondylosis.

Variant 12: Suspect Stress (Fatigue or Insufficiency) Fracture of the Long Bones. Pregnant Patient

See variant 11. In the case of long bones, the fetus's absorbed dose from radiography and CT will be substantially lower. Women can be reassured that benefit far outweighs the risk with regard to diagnostic imaging, as all radiographs and CT scans not involving the abdomen or pelvis have a predicted fetal absorbed dose of less than 1 mGy. Radiographs should be the initial imaging evaluation because findings may be conclusive, in which case no further imaging should be performed. MRI does not use ionizing radiation and can be used as necessary to make the diagnosis.

Summary of Recommendations

- In the setting of a suspected fatigue fracture, the initial imaging test should be radiography of the area of interest, although it is not a sensitive examination.
- If there is clinical concern for a fatigue fracture of the hip and initial radiographs are negative, MRI without contrast should be performed because of the high risk of complications.
- In the setting of a suspected fatigue fracture in a location other than the hip with initial negative radiographs, either repeat radiographs in 10 to 14 days or MRI without contrast may be appropriate depending on the location of pain and relative risk of complications secondary to stress fractures in that area.
- If there is an immediate need-to-know situation to diagnose a stress fracture in the setting of negative radiographs, for example, professional football player, then MRI without contrast is recommended.
- MRI without contrast and potentially total-body DXA provide prognostic information, which may help initial return-to-play evaluations.
- Although insensitive, radiographs should be the initial imaging study of choice for suspected insufficiency fractures in the pelvis or hip.
- When initial radiographs are negative in the setting of suspected insufficiency fracture of the pelvis or hip, MRI without contrast is recommended, and CT without contrast remains a reasonable, less sensitive alternative.
- Although insensitive, radiographs are the recommended initial imaging procedure for suspected insufficiency fractures in the lower extremities (excluding the pelvis and hip).
- When initial radiographs are negative in the setting of suspected insufficiency fracture of the lower extremities (excluding the pelvis and hip), MRI without contrast is recommended, and repeat radiographs in 10 to 14 days remains a reasonable, less sensitive alternative.
- When there is nonspecific focal uptake on a Tc-99m MDP bone scan suspected to be a stress fracture, dedicated radiographs are recommended, although MRI without contrast is a more sensitive alternative.
- For a suspected stress (fatigue or insufficiency) fracture in the pelvis of a pregnant patient, MRI without contrast is the initial imaging test of choice.
- When a stress (fatigue or insufficiency) fracture is suspected in the long bones of a pregnant patient, radiographs should be the initial imaging test of choice, with MRI performed as a complementary study if the radiographs are equivocal or negative.

Abbreviations

- CT, computed tomography
- DXA, dual-energy x-ray absorptiometry
- IV, intravenous
- MRI, magnetic resonance imaging
- SPECT, single-photon emission computed tomography
- Tc-99m, technetium-99 metastable
- US, ultrasound

Relative Radiation Level Designations

Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
O	0 mSv	0 mSv
☢	<0.1 mSv	<0.03 mSv
☢☢	0.1-1 mSv	0.03-0.3 mSv
☢☢☢	1-10 mSv	0.3-3 mSv
☢☢☢☢	10-30 mSv	3-10 mSv
☢☢☢☢☢	30-100 mSv	10-30 mSv

*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (e.g., region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies."

Clinical Algorithm(s)

Algorithms were not developed from criteria guidelines.

Scope

Disease/Condition(s)

Stress (fatigue/insufficiency) fractures including sacrum, excluding other vertebrae

Guideline Category

Diagnosis

Evaluation

Clinical Specialty

Emergency Medicine

Family Practice

Internal Medicine

Nuclear Medicine

Obstetrics and Gynecology

Orthopedic Surgery

Radiology

Rheumatology

Sports Medicine

Intended Users

Advanced Practice Nurses

Health Plans

Hospitals

Managed Care Organizations

Physician Assistants

Physicians

Students

Utilization Management

Guideline Objective(s)

To evaluate the appropriateness of imaging procedures for stress (fatigue/insufficiency) fractures including sacrum, excluding other vertebrae

Target Population

Patients with suspected stress (fatigue/insufficiency) fractures including sacrum, excluding other vertebrae

Interventions and Practices Considered

1. X-ray
    - Area of interest
    - Area of interest, repeat in 10 to 14 days
    - Lower extremity area of interest (not pelvis or hip)
    - Lower extremity area of interest (not pelvis or hip), repeat in 10 to 14 days
2. Magnetic resonance imaging (MRI)
    - Area of interest, without intravenous (IV) contrast
    - Area of interest, without and with IV contrast
    - Hip, without IV contrast
    - Hip, without and with IV contrast
    - Lower extremity area of interest (not pelvis or hip), without IV contrast
    - Lower extremity area of interest (not pelvis or hip), without and with IV contrast
3. Computed tomography (CT)
    - Area of interest, without IV contrast
    - Area of interest, with IV contrast
    - Area of interest, without and with IV contrast
    - Hip, without IV contrast
    - Hip, with IV contrast
    - Hip, without and with IV contrast
    - Lower extremity area of interest (not pelvis or hip), without IV contrast
    - Lower extremity area of interest (not pelvis or hip), with IV contrast
    - Lower extremity area of interest (not pelvis or hip), without and with IV contrast
4. Technetium (Tc)-99m bone scan whole body with single photon emission computed tomography (SPECT)
    - Area of interest
    - Hip
    - Lower extremity area of interest
5. Ultrasound
    - Area of interest
    - Hip
    - Lower extremity area of interest (not pelvis or hip)
6. Dual-energy x-ray absorptiometry (DXA) total body composition

Major Outcomes Considered

- Utility of imaging procedures in differential diagnosis of stress (fatigue/insufficiency) fracture, including sacrum, excluding other vertebrae
- Sensitivity, specificity, and accuracy of imaging procedures in the diagnosis and evaluation of stress (fatigue/insufficiency) fracture, including sacrum, excluding other vertebrae

Methodology

Methods Used to Collect/Select the Evidence

Hand-searches of Published Literature (Primary Sources)

Hand-searches of Published Literature (Secondary Sources)

Searches of Electronic Databases

Description of Methods Used to Collect/Select the Evidence

Literature Search Summary

Of the 40 citations in the original bibliography, 22 were retained in the final document.

A new literature search was conducted in August 2013, May 2015, and April 2016 to identify additional evidence published since the *ACR Appropriateness Criteria® Stress (Fatigue/Insufficiency) Fracture, Including Sacrum, Excluding Other Vertebrae* topic was finalized. Using the search strategies described in the literature search companion (see the "Availability of Companion Documents" field), 782 articles were found. Forty-four articles were added to the bibliography. The remaining articles were not used due to either poor study design, the articles were not relevant or generalizable to the topic, the results were unclear, misinterpreted, or biased, or the articles were already cited in the original bibliography.

The author added 13 citations from bibliographies, Web sites, or books that were not found in the new literature search.

Four citations are supporting documents that were added by staff.

See also the American College of Radiology (ACR) Appropriateness Criteria® literature search process document (see the "Availability of Companion Documents" field) for further information.

Number of Source Documents

Of the 40 citations in the original bibliography, 22 were retained in the final document. The new literature searches conducted in August 2013, May 2015, and April 2016 identified 44 articles that were added to the bibliography. The author added 13 citations from bibliographies, Web sites, or books that were not found in the new literature searches. Four citations are supporting documents that were added by staff.

Methods Used to Assess the Quality and Strength of the Evidence

Weighting According to a Rating Scheme (Scheme Given)

Rating Scheme for the Strength of the Evidence

Definitions of Study Quality Categories

Category 1 - The study is well-designed and accounts for common biases.

Category 2 - The study is moderately well-designed and accounts for most common biases.

Category 3 - The study has important study design limitations.

Category 4 - The study or source is not useful as primary evidence. The article may not be a clinical study, the study design is invalid, or conclusions are based on expert consensus.

The study does not meet the criteria for or is not a hypothesis-based clinical study (e.g., a book chapter or case report or case series description);

Or

The study may synthesize and draw conclusions about several studies such as a literature review article or book chapter but is not primary evidence;

Or

The study is an expert opinion or consensus document.

Category M - Meta-analysis studies are not rated for study quality using the study element method because the method is designed to evaluate individual studies only. An "M" for the study quality will indicate that the study quality has not been evaluated for the meta-analysis study.

Methods Used to Analyze the Evidence

Review of Published Meta-Analyses

Systematic Review with Evidence Tables

Description of the Methods Used to Analyze the Evidence

The topic author assesses the literature then drafts or revises the narrative summarizing the evidence found in the literature. American College of Radiology (ACR) staff drafts an evidence table based on the analysis of the selected literature. These tables rate the study quality for each article included in the narrative.

The expert panel reviews the narrative, evidence table and the supporting literature for each of the topic-variant combinations and assigns an appropriateness rating for each procedure listed in the variant table(s). Each individual panel member assigns a rating based on his/her interpretation of the available evidence.

More information about the evidence table development process can be found in the ACR Appropriateness Criteria® Evidence Table Development document (see the "Availability of Companion Documents" field).

Methods Used to Formulate the Recommendations

Expert Consensus (Delphi)

Description of Methods Used to Formulate the Recommendations

<u>Rating Appropriateness</u>

The American College of Radiology (ACR) Appropriateness Criteria (AC) methodology is based on the RAND Appropriateness Method. The appropriateness ratings for each of the procedures or treatments included in the AC topics are determined using a modified Delphi method. A series of surveys are conducted to elicit each panelist's expert interpretation of the evidence, based on the available data, regarding the appropriateness of an imaging or therapeutic procedure for a specific clinical scenario. The expert panel members review the evidence presented and assess the risks or harms of doing the procedure balanced with the benefits of performing the procedure. The direct or indirect costs of a procedure are not considered as a risk or harm when determining appropriateness. When the evidence for a specific topic and variant is uncertain or incomplete, expert opinion may supplement the available evidence or may be the sole source for assessing the appropriateness.

The appropriateness is represented on an ordinal scale that uses integers from 1 to 9 grouped into three categories: 1, 2, or 3 are in the category "usually not appropriate" where the harms of doing the procedure outweigh the benefits; and 7, 8, or 9 are in the category "usually appropriate" where the benefits of doing a procedure outweigh the harms or risks. The middle category, designated "may be appropriate," is represented by 4, 5, or 6 on the scale. The middle category is when the risks and benefits are equivocal or unclear, the dispersion of the individual ratings from the group median rating is too large (i.e., disagreement), the evidence is contradictory or unclear, or there are special circumstances or subpopulations which could influence the risks or benefits that are embedded in the variant.

The ratings assigned by each panel member are presented in a table displaying the frequency distribution of the ratings without identifying which members provided any particular rating. To determine the panel's recommendation, the rating category that contains the median group rating without disagreement is selected. This may be determined after either the first or second rating round. If there is disagreement after the second rating round, the recommendation is "May be appropriate."

This modified Delphi method enables each panelist to articulate his or her individual interpretations of the evidence or expert opinion without excessive influence from fellow panelists in a simple, standardized, and economical process. For additional information on the ratings process see the Rating Round Information document.

Additional methodology documents, including a more detailed explanation of the complete topic development process and all ACR AC topics can be found on the ACR Web site (see also the "Availability of Companion Documents" field).

Rating Scheme for the Strength of the Recommendations

Not applicable

Cost Analysis

A formal cost analysis was not performed and published cost analyses were not reviewed.

Method of Guideline Validation

Internal Peer Review

Description of Method of Guideline Validation

Criteria developed by the Expert Panels are reviewed by the American College of Radiology (ACR) Committee on Appropriateness Criteria.

Evidence Supporting the Recommendations

Type of Evidence Supporting the Recommendations

The recommendations are based on analysis of the current medical evidence literature and the application of the RAND/UCLA appropriateness method and expert panel consensus.

Summary of Evidence

Of the 83 references cited in the *ACR Appropriateness Criteria® Stress (Fatigue/Insufficiency) Fracture, Including Sacrum, Excluding Other Vertebrae* document, all are categorized as diagnostic references, including 4 good-quality studies and 15 quality studies that may have design limitations. There are 64 references that may not be useful as primary evidence.

Although there are references that report on studies with design limitations, 4 good-quality studies provide good evidence.

Benefits/Harms of Implementing the Guideline Recommendations

Potential Benefits

The use of magnetic resonance imaging (MRI) has greatly improved the ability to diagnose radiographically occult stress fractures. Both fatigue and insufficiency fractures are now being more frequently recognized as a source of pain in patients, and although fatigue and insufficiency fractures can be self-limited and go on to healing with or without diagnosis, there is usually value in making the diagnosis. With continued activity, some stress injuries and incomplete (unicortical) stress fractures will progress to completion and require more invasive treatment or delay in return to activity. Also, the differential diagnosis of fatigue/insufficiency fractures includes entities that would be treated significantly differently than stress fractures (osteoid osteoma or osteomyelitis in the younger patient, metastases in the older patient). The clinical picture is further clouded by the fact that many older patients with insufficiency fractures have histories of previous malignancy.

Potential Harms

- In elderly or osteoporotic patients, abnormalities may not show up in bone scans for several days post-injury. Patients using corticosteroids may also have less sensitive results.
- False-positive or false-negative results of tests
  - A circumstance that deserves specific attention is the longitudinal stress fracture, particularly in the tibia. Up to 25% may appear normal on radiographs, but computed tomography (CT) or magnetic resonance imaging (MRI) findings are characteristic. MRI is very sensitive to the bone marrow edema accompanying these longitudinal fractures and may give a misleadingly aggressive appearance. Axial CT alone can have false negatives because of the constraint of the axial plane (in one study, half of stress fractures were inadequately demonstrated on CT). Therefore, if CT is used to confirm stress fracture in a long bone, multiplanar reformatting is necessary. Fine detail can be achieved using thinner sections.
  - Although bone scintigraphy is very sensitive for stress reactions and osteoblastic metastases, in most cases it lacks specificity, with synovitis, arthritis, degenerative joint disease, stress reactions, and tumor appearing similar. Supplemental imaging with radiographs, MRI, or CT may be necessary for conclusive diagnosis or to avoid false positives.

Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, both because of organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared to those specified for adults. Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® Radiation Dose Assessment Introduction document (see the "Availability of Companion Documents" field).

Qualifying Statements

Qualifying Statements

- The American College of Radiology (ACR) Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists, and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the U.S. Food and Drug Administration (FDA) have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.
- ACR seeks and encourages collaboration with other organizations on the development of the ACR Appropriateness Criteria through society representation on expert panels. Participation by representatives from collaborating societies on the expert panel does not necessarily imply

society endorsement of the final document.

Implementation of the Guideline

Description of Implementation Strategy

An implementation strategy was not provided.

Institute of Medicine (IOM) National Healthcare Quality Report Categories

IOM Care Need

Getting Better

IOM Domain

Effectiveness

Identifying Information and Availability

Bibliographic Source(s)

Bencardino JT, Stone TJ, Roberts CC, Appel M, Baccei SJ, Cassidy RC, Chang EY, Fox MG, Greenspan BS, Gyftopoulos S, Hochman MG, Jacobson JA, Mintz DN, Mlady GW, Newman JS, Rosenberg ZS, Shah NA, Small KM, Weissman BN, Expert Panel on Musculoskeletal Imaging. ACR Appropriateness CriteriaÂ® stress (fatigue/insufficiency) fracture, including sacrum, excluding other vertebrae. Reston (VA): American College of Radiology (ACR); 2016. 17 p. [83 references]

Adaptation

Not applicable: The guideline was not adapted from another source.

Date Released

2016

Guideline Developer(s)

American College of Radiology - Medical Specialty Society

Source(s) of Funding

The American College of Radiology (ACR) provided the funding and the resources for these ACR Appropriateness Criteria®.

Guideline Committee

Committee on Appropriateness Criteria, Expert Panel on Musculoskeletal Imaging

Composition of Group That Authored the Guideline

Panel Members: Jenny T. Bencardino, MD (*Principal Author and Panel Vice-chair*); Taylor J. Stone, MD (*Research Author*); Catherine C. Roberts, MD (*Panel Chair*); Marc Appel, MD; Steven J. Baccei, MD; R. Carter Cassidy, MD; Eric Y. Chang, MD; Michael G. Fox, MD; Bennett S. Greenspan, MD, MS; Soterios Gyftopoulos, MD; Mary G. Hochman, MD; Jon A. Jacobson, MD; Douglas N. Mintz, MD; Gary W. Mlady, MD; Joel S. Newman, MD; Zehava S. Rosenberg, MD; Nehal A. Shah, MD; Kirstin M. Small, MD; Barbara N. Weissman, MD (*Specialty Chair*)

Financial Disclosures/Conflicts of Interest

Not stated

Guideline Status

This is the current release of the guideline.

This guideline updates a previous version: Daffner RH, Weissman BN, Appel M, Bancroft L, Bennett DL, Blebea JS, Bruno MA, Fries IB, Hayes CW, Kransdorf MJ, Luchs JS, Morrison WB, Palestro CJ, Roberts CC, Stoller DW, Taljanovic MS, Tuite MJ, Ward RJ, Wise JN, Zoga AC, Expert Panel on Musculoskeletal Imaging. ACR Appropriateness Criteria® stress (fatigue/insufficiency) fracture, including sacrum, excluding other vertebrae. [online publication]. Reston (VA): American College of Radiology (ACR); 2011. 9 p. [40 references]

This guideline meets NGC's 2013 (revised) inclusion criteria.

Guideline Availability

Available from the American College of Radiology (ACR) Web site.

Availability of Companion Documents

The following are available:

- ACR Appropriateness Criteria®. Overview. Reston (VA): American College of Radiology; 2015 Oct. 3 p. Available from the American College of Radiology (ACR) Web site.
- ACR Appropriateness Criteria®. Literature search process. Reston (VA): American College of Radiology; 2015 Feb. 1 p. Available from the ACR Web site.
- ACR Appropriateness Criteria®. Evidence table development. Reston (VA): American College of Radiology; 2015 Nov. 5 p. Available from the ACR Web site.
- ACR Appropriateness Criteria®. Topic development process. Reston (VA): American College of Radiology; 2015 Nov. 2 p. Available from the ACR Web site.
- ACR Appropriateness Criteria®. Rating round information. Reston (VA): American College of Radiology; 2015 Apr. 5 p. Available from the ACR Web site.
- ACR Appropriateness Criteria®. Radiation dose assessment introduction. Reston (VA): American College of Radiology; 2016. 4 p. Available from the ACR Web site.
- ACR Appropriateness Criteria®. Manual on contrast media. Reston (VA): American College of Radiology; 2016. 128 p. Available from the ACR Web site.
- ACR Appropriateness Criteria®. Procedure information. Reston (VA): American College of Radiology; 2016 May. 2 p. Available from the ACR Web site.
- ACR Appropriateness Criteria® stress (fatigue/insufficiency) fracture, including sacrum, excluding other vertebrae. Evidence table. Reston

(VA): American College of Radiology; 2016. 30 p. Available from the ACR Web site .
- ACR Appropriateness Criteria® stress (fatigue/insufficiency) fracture, including sacrum, excluding other vertebrae. Literature search. Reston (VA): American College of Radiology; 2016. 2 p. Available from the ACR Web site .

Patient Resources

None available

NGC Status

This NGC summary was completed by ECRI on May 6, 2001. The information was verified by the guideline developer as of June 29, 2001. This summary was updated by ECRI on March 28, 2006. This summary was updated by ECRI Institute on June 29, 2009. This summary was updated by ECRI Institute on July 7, 2011. This summary was updated by ECRI Institute on January 10, 2017.

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